The Effect of Education on Political Knowledge: Evidence From Monozygotic Twins

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Abstract

Political scientists have long been interested in the determinants of political knowledge. In many studies, education is the strongest predictor of political knowledge. However, some studies have found that education has no effect on knowledge once confounding variables are taken into account. In addition, some recent work suggests that education remains the strongest predictor of knowledge even after accounting for confounders like personality traits and intelligence. We provide new evidence on the effect of education on political knowledge by utilizing the co-twin control design. By looking at the relationship between education and knowledge within monozygotic twin pairs, we are able to circumvent sources of confounding of the relationship due to genetic factors and early-life family environment because monozygotic twins share both. We find that the relationship between education and political knowledge is highly confounded by genes and/or familial environment. The results from a naive model that does not take into account unobserved family factors indicate that education has a positive and statistically significant effect on political knowledge. However, in a twin fixed-effects model that accounts for confounding due to genetic factors and familial socialization, we find that the effect of education on

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political knowledge drops substantially and is not statistically significant at conventional levels.

Introduction

Political knowledge is a central concept in the political behavior literature. Indeed, scholars have spent a great deal of time trying to identify its causes and consequences (Arceneaux, Johnson, & Maes, 2012; Delli Carpini & Keeter, 1996; Galston, 2001; Highton, 2009; Luskin, 1990).[1] Theoretical accounts of democratic citizenship and empirical studies in political behavior suggest that political knowledge is important because it underlies many desirable behaviors and attitudes, including political participation and political tolerance. In summarizing the consequences of political knowledge, Delli Carpini and Keeter (1996) note that "all things being equal, the more informed people are, the better able they are to perform as citizens" (p. 219).

Scholarship on the determinants of political knowledge has shown that a variety of factors influence political knowledge, including numerous demographic attributes and some environmental factors. One finding that has emerged across many studies is a positive relationship between educational attainment and political knowledge. In their seminal work on political knowledge, Delli Carpini and Keeter (1996) find that even in the presence of 19 demographic and attitudinal control variables, education is "the strongest single predictor of political knowledge" (p. 188). The finding that education positively impacts political knowledge has not gone unscrutinized, however. Some scholars have noted that the relationship between education and political knowledge is likely confounded by other variables, such as personality traits and cognitive ability, both of which are partially heritable, family background, and/or socialization. In fact, Highton (2009) goes so far as to argue that

> due to interpretative difficulties relating to cognitive skill and the exclusion of factors that likely cause sophistication and are also related to educational attainment, virtually all previous studies of the causes of political sophistication are severely limited in their ability to ascertain whether the variable most commonly associated with sophistication is actually a cause of it. (p. 1566)

In this research note, we provide new evidence on the effect of education on political knowledge. As we describe below, there is disagreement across

empirical studies about the extent to which education exerts a causal effect on political knowledge. In light of this debate, it is critical to develop an understanding of whether the relationship between education and political knowledge is causal or confounded. If, after several decades of research on the underpinnings of political knowledge, we remain unsure whether or not the relationship between education and knowledge is causal, then our understanding of political knowledge would appear to lack depth. Importantly, if it turns out that education and knowledge are correlated but not causally related, then many scholars have been misinterpreting the link between these two variables for some time now.[2] Our goal is to clarify the nature of the relationship between educational attainment and political knowledge.[3] We follow the recent line of quasi-experimental research by using a design not previously employed to study the effect of education on political knowledge—the so-called "co-twin control design" (McGue, Osler, & Christensen, 2010), in which the association between education and knowledge is analyzed *within* monozygotic (MZ) twin pairs. The strength of this design lies in the fact that MZ twins are genetically identical and have been exposed to the same family environment (given that they grew up together), which allows us to bypass some of the most likely unobserved variables threatening to bias the estimated impact of education on political knowledge, such as early-life socialization in the family and heritable psychological traits.[4]

Existing Evidence

Many studies have examined the relationship between education and political knowledge, and scholars often make the assumption that education plays a causal role in fostering political knowledge.[5] It is worth noting that many studies on the relationship between education and knowledge about politics, including foundational work by Delli Carpini and Keeter (1996), rely on cross-sectional survey data. Of course, one key concern when using cross-sectional surveys is that it can be difficult to sort out questions about causality—Unmeasured factors may affect the relationship between cause and effect.

There are a number of possible factors that might confound the relationship between education and political knowledge. Cognitive ability is an obvious potential confounder. As Highton (2009) points out, cognitive ability likely fosters political knowledge and influences whether one attends and graduates from college. Personality traits are another possible source of confounding. The Big Five personality traits, for example, are correlated with political knowledge (Gerber, Huber, Doherty, & Dowling, 2011a, 2011b; Mondak, 2010) and educational attainment (Anger, 2013; van Eijck & de

Graaf, 2004). Previous studies have demonstrated that both cognitive ability and personality traits are partially heritable (Deary, Spinath, & Bates, 2006; Haworth et al., 2009; Jang, Livesley, & Vernon, 1996; Loehlin, McCrae, Costa, & John, 1998). Political socialization is yet another potential confounding variable. Family experiences (or attributes like socioeconomic status) may influence one's educational attainment and political knowledge (Highton, 2009).

A few studies have attempted to account for some of the confounders mentioned above. For example, Luskin (1990) is able to include a measure of intelligence in his model of political knowledge; he makes use of interviewer ratings of respondent intelligence. He finds that intelligence has an important effect on knowledge but that education does not have an independent effect, suggesting that the effect of education on knowledge is confounded. In a more recent study, Rasmussen (2016) uses data from two cross-sectional surveys conducted in Denmark and finds that education remains an important predictor of political knowledge even after accounting for intelligence and the Big Five personality traits.[6] In a departure from Luskin (1990) and Rasmussen (2016), both of whom attempted to include some possible confounders but were only able to use cross-sectional data, Highton (2009) uses data from four waves of the Youth-Parent Socialization Study, a well-known panel study in political science. He finds that

> Differences in political knowledge associated with attending and graduating from college that are apparent when people are in their 20s, 30s, and 50 are not caused by attending college because the differences are evident when people are 18 before any college education has taken place. Factual political knowledge is caused by factors that are also associated with attending and graduating from college. (Highton, 2009, p. 1570)

Given the different conclusions that have emerged across the studies outlined above, we believe that the question of whether education has a causal effect on knowledge is very much an open one and there is ample reason to look for research designs that can help us control for the influence of heritable psychological traits (e.g., personality and cognitive ability) and the early-life environment. As Highton (2009) notes,

> From the perspective of this line of research, shifting attention to variation in sophistication among 18-year-olds may not go back far enough. Nevertheless, research on genetics and the results reported in this paper imply that there is much more to be learned by shifting attention away from adult attributes that are correlated with political characteristics and toward a focus on factors that underlie them both. (p. 1574)

In the next section, we describe how the use of data on MZ twins can provide insights on the nature of the relationship between educational attainment and knowledge about politics.

The Co-Twin Control Design

In this article, we use the quasi-experiment of twinning to study the effect of education on political knowledge. There are many examples in the political science literature of using data on twins to study the genetic and environmental sources of variance in political traits (Alford, Funk, & Hibbing, 2005; Dawes et al., 2014; Fowler, Baker, & Dawes, 2008; Settle, Dawes, & Fowler, 2009), which is typically done by comparing the phenotypic correlation among MZ twins, who are genetically identical, with the correlation among dizygotic twins, who share half of their genes. In this study, we instead employ twin data for a different purpose: to estimate the impact of education on political knowledge using the co-twin control design.[7] The strength of the co-twin control design, which typically makes use of just MZ twin pairs, stems from the fact that MZ twins are genetically identical and have been exposed to the same family environment. Thus, by relating within-pair differences in education to within-pair differences in political knowledge, we are able to estimate the impact education net of confounding factors rooted in genetic predispositions and early rearing environment. In effect, we will use one twin in a pair as the co-twin's credible (although not perfect) counterfactual (McGue et al., 2010).

Following previous work (Ashenfelter & Zimmerman, 1997; Isacsson, 1999; Oskarsson, Dinesen, Dawes, Johannesson, & Magnusson, 2017), we assume that the true relationships between education and political knowledge are

$$Y_{1j} = \beta X_{1j} + F_j + \epsilon_{1j}, \tag{1a}$$

$$Y_{2j} = \beta X_{2j} + F_j + \epsilon_{2j}, \tag{1b}$$

where Y denotes political knowledge and X is the measure of educational attainment i $(1,2)$ in pair j $(1,2,..,N)$. The error term in each equation consists of an individual-specific component (ϵ_{ij}) and a family-specific component (F_j). The family-specific effects vary across but not within twin pairs and capture unobserved family background and unobserved genetic traits potentially influencing both education and political knowledge.

Differencing Equations 1a and 1b controls for family effects:

$$Y_{1j} - Y_{2j} = \beta_{FE}(X_{1j} - X_{2j}) + (\epsilon_{1j} - \epsilon_{2j}), \tag{2}$$

where β_{FE} represents the within-twin-pair estimate of the effect of education on knowledge. Because MZ twins are genetically identical and assumed to have the same rearing environment, the estimate of β_{FE} is not biased by these unmeasured factors. In addition to the assumption about the same rearing environment, it is important to note that the co-twin design makes the assumption that differences in education are exogenous conditional on the fixed effects. An important question following this assumption is what may cause such differences in otherwise similar individuals. Indeed, even though differencing will remove the influence of unobserved factors common to twin pairs, if differences in education *within twin* pairs are not exogenously given, it is possible that there are still within-twin-pair differences in unobserved factors that affect educational attainment. Fortunately, this question has been taken up by Lundborg (2013), who provides numerous examples of exogenously given differences in educational attainment. Comfortingly, Lundborg (2013) finds that numerous factors that may vary within twin pairs (e.g., birth weight, early-life health, parent–child relations) do not predict within-twin-pair differences in schooling. This finding supports the notion that differences in schooling within twin pairs are exogenous, which suggests that the co-twin design is a valid way to study the effects of education.

We are only aware of two studies in political science that have used this approach. In the first study to use the co-twin control design, Dinesen et al. (2016) used data from identical twins in Denmark, Sweden, and the United States to examine the effect of education on political participation.[8] Interestingly, they found that while the relationship between education and political participation was highly confounded by genes and/or familial environment, a positive impact remained in some contexts (the United States and Denmark). Oskarsson et al. (2017) also adopted this approach to examine the effect of education on social trust in Sweden. They found that after accounting for early-life socialization in the family and heritable psychological traits, the estimated effect of education on social trust was close to zero and not statistically significant.

Data and Measures

Minnesota Twins Political Survey (MTPS)

Our data come from the MTPS, which is a dataset that was collected based on a sample of twins from the Minnesota Twin Family Registry.[9] The dataset is

designed to allow researchers to explore genetic and environmental sources of variance on a wide range of political traits. The MTPS data were collected using a web survey in 2008, followed by a paper-and-pencil survey in 2009.[10] The MTPS has been widely used in political science, usually to estimate univariate or bivariate heritability models (see, e.g., Arceneaux et al., 2012; Cranmer & Dawes, 2012; Klemmensen et al., 2012; Klemmensen, Hatemi, Hobolt, Skytthe, & Nørgaard, 2012; Littvay, 2012; Littvay, Weith, & Dawes, 2011; Orey & Park, 2012; Verhulst, 2012), but we are not aware of any studies that have used this dataset to examine the impact of education on political knowledge using the co-twin control design. One of the two studies mentioned above (Dinesen et al., 2016) that has employed the co-twin control design used the MTPS, but the focus was on participation in political activities and not factual knowledge about government and politics.

Before describing the variables of interest in this study, we should note that one concern when using the co-twin control design for estimating causal relationships is the question of whether MZ twins are representative of the general population and therefore whether the estimates obtained from twin samples are externally valid. In the Online Appendix, we present analyses that gauge the representativeness of the MTPS. Based on these analyses, we believe that the estimates based on the Minnesota sample we use are, at least to some extent, externally valid.

Dependent Variable

To measure political knowledge, we make use of a battery of factual items that was included in the survey. Respondents were asked five questions about political processes and U.S. institutions, including who is responsible for deciding if a law is constitutional (U.S. Supreme Court), who nominates judges to federal courts (President), which major political party is more conservative at the national level (Republicans), the required majority for the U.S. Congress to override a presidential veto (two thirds majority), and the main duty of the U.S. Congress (to write laws). For each question, respondents were given a number of possible answers to choose from; "Unsure" was also listed as a response for each question. We coded correct answers to each question as a "1" and incorrect answers as a "0." We also coded unsure responses as "0." Consistent with previous research on political knowledge, we summed correct responses to the five questions.[11] The overall measure is quite reliable (Kuder-Richarson coefficient of reliability, which is used when items are dichotomous, is 0.6974).[12] It is important to note that while MZ twins may be expected to be very alike in terms of political knowledge, there is within-pair variation in knowledge. Indeed, the mean absolute difference in

political knowledge is 0.977 (*SD* = 1.024), which is fairly substantial given that our knowledge measure ranges from 0 to 5.[13]

Independent Variable

To measure education, we use a question that asked respondents to identify the highest level of education they have completed. The response categories were as follows: (a) Grades 1 to 12, did not graduate from high school, (b) high school graduate, (c) some trade or technical training after high school, (d) some college or associate's degree, (e) college degree, (f) professional or graduate training or degree after college. We employ two different operationalizations of education. Our initial operationalization is simply an ordinal measure that makes use the six categories listed above. Importantly, the effect of education may be nonlinear due to threshold effects of having completed different stages of education. Indeed, some studies have pointed out the importance of attending college for political knowledge (see, e.g., Delli Carpini & Keeter, 1996). Therefore, we also develop a dummy variable indicating whether a respondent has a college degree or higher.

    Given that co-twin control models only use within-twin variation to estimate the impact of the independent variable, it is crucial that there is sufficient variation in education between twins within a pair to be able to detect an effect on knowledge. If not, any absence of significant effects may reflect lack of statistical power. To assess this concern, we examined the variation in education within twin pairs in the Online Appendix. While MZ twins, unsurprisingly, resemble each other in terms of education, it is also clear that there is some within-pair variation in education. In terms of years of education, the average absolute difference in years of education between twins is 0.690 (*SD* = 0.772). In addition, 17.8% of the pairs differ in having attended college. As a consequence, examining the effect of education on political knowledge based on differences in education among twins is a worthwhile endeavor.

Results

In Table 1, we report estimates of the effects of our two measures of education on political knowledge. For each conceptualization of education, we report two sets of estimates. First, we present naive ordinary least squares (OLS) estimates (controlling for birth year and sex) in which twins are treated as individuals without regard to their membership in a twin pair and unobserved family factors are not taken into account. This is the typical way of assessing the effect of education on political knowledge (i.e., this is how one would examine the effect if using cross-sectional survey data). Second, we

Table 1. OLS and Twin-Pair FE Estimates of the Effect of Education on Political Knowledge With Standard Errors in Parentheses.

	OLS	FE	OLS	FE
Education	0.495***	0.137†		
	(0.039)	(0.074)		
College			1.248***	0.131
			(0.104)	(0.181)
Birth year	−0.043†		−0.045*	
	(0.022)		(0.022)	
Male	0.587***		0.637***	
	(0.111)		(0.115)	
Intercept	86.110*	3.030***	90.798*	3.525***
	(43.349)	(0.297)	(43.677)	(0.080)
N	684	684	684	684
Between R^2		.312		.271
Within R^2		.010		.002
Overall R^2	.268	.226	.229	.179

Note. In all of the OLS models, standard errors are clustered by twin pair. OLS = ordinary least squares; FE = fixed effects.
Significance levels: †$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

present twin-pair fixed-effects estimates, which gauge the within-pair impact of education on political knowledge. These are the estimates of primary interest, but it is important to present the OLS estimates because they function as benchmarks against which the fixed-effects models that account for confounding due to genetic factors and familial socialization can be compared. All of the analyses shown in Table 1 are based on 342 MZ twin pairs (684 twins) reared together with nonmissing responses for political knowledge questions and educational attainment.

A number of important findings emerge from Table 1. A look at the naive OLS estimates indicates that there is a strong, positive relationship between education and political knowledge. This is consistent with what many previous studies have reported (Barabas, Jerit, Pollock, & Rainey, 2014; Delli Carpini & Keeter, 1996; Mondak & Anderson, 2004). A comparison between the OLS estimates and the twin-pair fixed-effects estimates, however, indicates that the OLS estimates are *severely upward biased*, and once confounding stemming from genetic factors and familial socialization is taken into account in the twin-pair fixed-effects models, the estimated effect of education on knowledge drops dramatically in the models shown in Table 1. In the models that use the ordinal measure measure of education, the education
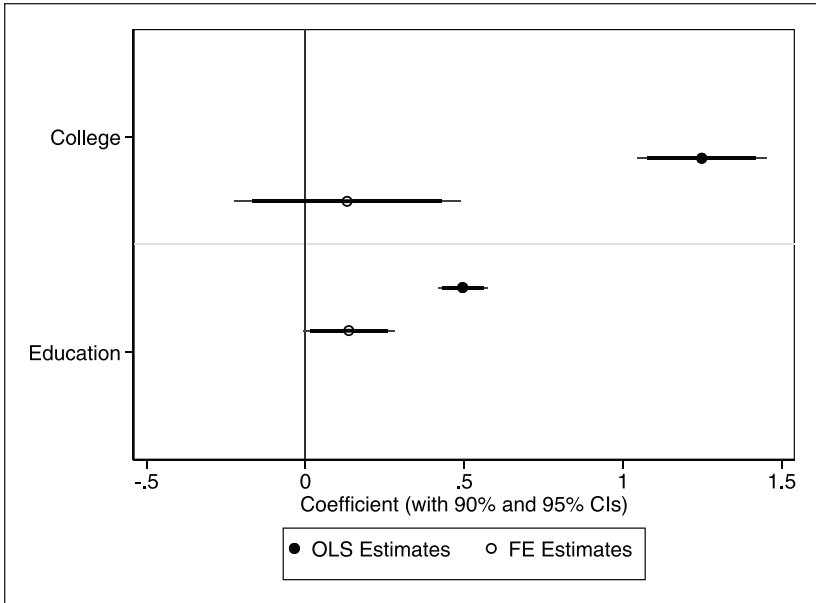
Figure 1. Comparison of OLS and FE estimates of the effect of education on political knowledge.
Note. CI = confidence interval; OLS = ordinary least squares; FE = fixed effects.

coefficient drops from 0.495 (*p* < .001) in the OLS specification to 0.137 in the twin-pair fixed-effects specification, which amounts to a 72% reduction in the magnitude of the effect. In the twin-pair fixed-effects model, the coefficient is only statistically significant if one is willing to stretch the level of significance to the *p* < .10 level (90% confidence interval [CI] is [.002, .129]). In the models that use a dummy variable to measure whether one has a college degree or higher, there is an even more pronounced reduction in the effect of education across the models. In the OLS model, the coefficient on the college education variable is 1.248 (*p* < .001), but in the twin-pair fixed-effects model, the coefficient drops to 0.131, which is a 90% decrease in the magnitude of the coefficient. In addition, the coefficient is not statistically significant in the fixed-effects model. A look at Figure 1, which plots the education coefficient (and CIs) from the four models shown in Table 1, helps to visualize the reduction in the magnitude of the education effects when comparing the OLS results to the fixed-effects results. Overall, these results show that the concern over confounding of the relationship between education and political knowledge by genetic factors and familial environment is well directed.

As a robustness check, we constructed an alternative measure of political knowledge using an item response theory (IRT) model.[14] We then used this measure of political knowledge as the dependent variable and reran the models in Table 1. Due to the similarity of results, we present the model results in the Online Appendix for interested readers. Comfortingly, we find that an alternative measurement approach does not alter the conclusions we draw. Indeed, the patterns of statistical significance are the same and the reduction in the magnitude of the effect of education when comparing the OLS and fixed-effects models is very similar.[15]

Limitations

It is important to be clear about both the strengths and the weaknesses of the co-twin control design. On one hand, this approach enables a very strong control for unobservable or hard-to-measure traits emanating from individual differences in genetic factors and early-life environment. On the other hand, because this approach is based on observational data, it does not provide us with definitive causal estimates as the estimated impact of education on knowledge may still be confounded by experiences unique to each twin in a pair. Indeed, this design builds on an important assumption, namely, that the factors explaining within-twin-pair differences in education are uncorrelated with political knowledge. As a consequence, if twins within a pair—as a result of experiences unique to each twin—differ in cognitive ability, personality, or any other variable affecting (and, importantly, *preceding*) both schooling and political knowledge, the estimated effect of education will be biased.[16] As Dinesen et al. (2016) note, although it may seem desirable to include measures of cognitive ability and personality directly in the fixed-effects models to gauge within-twin-pair differences in these traits, both may also be a result, and not only a cause, of education (see, e.g., Dahmann & Anger, 2014; Falch & Massih, 2011) with posttreatment bias as a consequence. Ultimately, to strengthen the leverage for studying causal effects further, we hope that future scholars will try to overcome the potential remaining within-twin-pair confounding by measuring these phenomena directly (e.g., by measuring experiences unique to each twin).

Another potential concern with the results presented above is measurement error in education. Of course, measurement error is a problem inherent in all research using crude (typically self-reported) measures of education, but measurement error in the explanatory variable is exacerbated when differencing, especially when differencing between identical twins (Griliches, 1979). This could lead to attenuation bias (i.e., bias toward no effect) in the within-pair estimate of the effect of education on knowledge. Unfortunately,

we cannot account for measurement error because we do not have any test–retest results within our sample (we only have one survey question measuring educational attainment). Comfortingly, though, one recent study on the effect of education on social trust (using the co-twin control design) in a sample of Swedish identical twins found that

> correcting the schooling variables for common levels of measurement error does not affect the estimated effects of education on social trust in any substantive way. The reported within-pair estimates of the influence of educational attainment on social trust are all small in magnitude, often incorrectly signed, and never statistically significant irrespective of the assumed level of measurement error in the schooling variables. This suggests that the absence of effect of education on social trust in the twin-pair models does not reflect possible measurement error. (Oskarsson et al., 2017, p. 524)

We are not aware of any other twin studies that have measures of factual knowledge about politics, but we encourage the collection of additional datasets on twins that contain such measures and multiple measure of educational attainment. We hope that future researchers will consider replicating this study and other studies that employ the co-twin control design.

Conclusion and Future Research

In this article, we were interested in examining the effect of education on political knowledge. The conventional wisdom is that education exerts a causal effect on political knowledge. However, some scholars have noted that the effect of education on knowledge about politics could be confounded by early-life socialization in the family as well as heritable psychological traits like cognitive ability and personality traits. In recent years, conflicting evidence has emerged regarding the extent to which education causes political knowledge. Some studies find *no effect* after accounting for confounders (Highton, 2009; Luskin, 1990), while others find that education *still* has an effect even after taking into account confounders (Rasmussen, 2016).[17] Our primary contribution was to utilize a different approach than has been employed in the past to study the impact of education on political knowledge. Conducting "within-twin-pair" analyses allowed us to bypass some of the most likely unobserved variables threatening to bias the estimated impact of education on political knowledge. We found that the relationship between education and political knowledge is highly confounded by genetic factors and/or familial environment. Thus, our results mesh well with analyses by scholars like Highton (2009), who used the Jennings and Niemi Youth-Parent Socialization Panel Study, and concluded that " . . . there appears to be no

significant effect of attending and graduating from college on political awareness" (p. 1564).

Although we applied the co-twin control design to the study of the effect of education on political knowledge, we believe that future research could benefit from using this approach. For example, scholars could examine the effect of education on other political orientations, like civic duty, political interest, and political efficacy, using the co-twin design. Education is often a strong predictor of these orientations (see, e.g., Blais & Labbé-St-Vincent, 2011; Gimpel, Kaufmann, & Pearson-Merkowitz, 2007; Vecchione & Caprara, 2009), but it is possible that the effect of education is confounded by genetic factors and/or familial environment. In addition to studying other orientations, it would be interesting to study the effect of education on political orientations in contexts outside of the United States. We were restricted to using a U.S. sample because we are not aware of any other twin studies that contain measures of political knowledge.[18] In the end, we believe that the co-twin control design can help researchers develop a better understanding of relationships that may theoretically be confounded by heritable psychological factors and early-life family environment.

An important concern when evaluating the relationship between education and political knowledge is that unobserved characteristics may affect both the choice to acquire education and the decision to inform oneself about politics. Rather than being the cause of political knowledge, education may be proxying for genetic factors. By utilizing a within-family analysis, our research design accounts for genetic factors (and family environment). A recently developed alternative approach, which does not rely on an analysis of siblings, is to directly control for genetic factors by creating a so-called "polygenic score" that summarizes the effect of genes associated with educational attainment. The polygenic score is constructed to maximize predictive power for educational attainment by using information from a large (well-powered) genome-wide association study (Dudbridge, 2013). A recently published genome-wide association study of educational attainment, based on a sample of over one million individuals, provides social scientists an opportunity to construct a polygenic score that accounts for approximately half of the heritable variation in education (Lee et al., 2018). Ideally, future studies of the relationship between education and political knowledge will be able to use this approach to directly control for genetic confounding.

Declaration of Conflicting Interests

Notes

1. It has also been called political sophistication, political awareness, and political expertise. We use the terms interchangeably. In this article, we are interested in factual knowledge about government and politics.

2. In many studies, education is a central variable of interest. However, as Persson (2014) notes, "If education is used as a control variable and captures the effects of other variables correlated with the main variables of interest in the analyses, the interpretation of the estimates will be problematic. Hence, even if education is used only as a control variable, it is important to understand what the relationship actually means and what it controls for" (p. 701).

3. Researchers in other areas of political science (e.g., political psychology) are increasingly taking up the question of correlation versus causation. For example, a series of studies have shown that the relationship between personality and ideology, which is typically viewed as causal, may not be causal in nature (see, e.g., Hatemi & Verhulst, 2015; Verhulst, Eaves, & Hatemi, 2012; Verhulst, Hatemi, & Martin, 2010).

4. We note the psychological traits are highly but not exclusively heritable.

5. For example, Delli Carpini and Keeter (1996) argue that "The primacy of formal education as a *facilitator of political knowledge* lies in its relevance to all the components of the opportunity-motivation-ability triad: it promotes the opportunity to learn about politics by transmitting specific information and influencing career paths and social networks; it increases the motivation by socializing students to the political world and stimulating their interest in it; and it develops the cognitive ability necessary for effective learning" (p. 190, italics added for emphasis). They go on to point out that "All education, but especially college, has a powerful effect on political knowledge through the development of skills and orientations that make it easier for the well schooled to comprehend and retain political information" (pp. 192-193). Niemi and Junn (2005) also make a similar point, noting that "there is virtual unanimity on one point: formal education is the strongest, most consistent correlate (and is widely considered *the central causal determinant*) of political knowledge. This finding has been replicated in study after study . . . Regardless of how political knowledge is measured, formal education is the single most important factor differentiating those who know more about politics from those who know less. Citizens who spend more years in school simply know a lot more about politics" (p. 13, italics added for emphasis).

6. Highton (2009) sees a concern with this approach. He points out that "Including cognitive ability in models of political sophistication helps, but still leaves open the question of causality. Ability is difficult to gauge, and as a result, the measures

used for it will be less than perfectly reliable. Even if the measurement problem was addressed and the inclusion of a measure of cognitive ability eliminated the apparent effect of education, an interpretative problem would remain. Education might proxy cognitive ability, implying no true causal effect of education. Or, the elimination of the apparent effect of education on sophistication with the inclusion of cognitive ability may indicate why education matters" (pp. 1565-1566).

7. The co-twin control design is also sometimes referred to as the discordant twin design.

8. There is an ongoing debate about the extent to which education causes political participation and this study attempts to contribute to the question of whether education exerts a causal effect. For examples of different approaches (none of which use the co-twin control design), see the following studies: Berinsky and Lenz (2011); Kam and Palmer (2008); Hillygus (2005); Henderson and Chatfield (2011); Kam and Palmer (2011); Mayer (2011); Persson (2012, 2014). In addition, see Persson (2015) for a detailed review of the literature.

9. The registry contains 8,000 pairs of twins born between 1936 and 1956 in Minnesota.

10. The data employed in this project were collected with the financial support of the National Science Foundation in the form of SES-0721378, PI: John R. Hibbing; Co-PIs: John R. Alford, Lindon J. Eaves, Carolyn L. Funk, Peter K. Hatemi, and Kevin B. Smith, and with the cooperation of the Minnesota Twin Registry at the University of Minnesota, Robert Krueger and Matthew McGue, Directors.

11. 5.41% got zero correct, 6.87% got 1 correct, 11.40% got 2 correct, 15.20% got 3 correct, 23.25% got 4 correct, and 37.87% got all 5 correct.

12. The range is 0 to 1, where 0 is no reliability and 1 is perfect reliability.

13. Table with analyses is provided in the Online Appendix.

14. The summary measure we use in Table 1 (where we simply added up the number of correct answers so that respondents get a score ranging from 0-5) would fall under classical test theory (CTT). For the IRT approach, we fit a three-parameter logistic (3PL) model, which is used for binary items. In the 3PL model, items vary in their difficulty and discrimination and the possibility of guessing is allowed. We thank an anonymous reviewer for this idea.

15. In the models that use the IRT measure of knowledge, the effect of education (when using the ordinal measure) drops by 75.47% when comparing the OLS results to the FE results. That is similar to the 72% reduction in the magnitude of the effect (based on the results in Table 1 above). In the models that use the IRT measure of knowledge, the effect of education (when using the college or higher measure) drops by 91.6% when comparing the OLS results to the FE results. That is similar to the 89.5% reduction in the magnitude of the effect (based on the results in Table 1 above).

16. While it is difficult to rule out this form of confounding altogether, we can go some way in addressing one possible confounder in this regard: differential treatment during childhood. In the Online Appendix, we provide some preliminary evidence indicating that our estimate of the impact of education on political

knowledge is not confounded by differential experiences during childhood.

17. Rasmussen (2016) finds evidence that education is partially confounded by psychological predispositions but notes that it still "retains a strong independent impact on political knowledge" (p. 1046).

18. Using the co-twin design, Dinesen et al. (2016) were able to utilize three twin studies from the United States, Denmark, and Sweden to examine the effect of education on political participation, and we encourage future scholars to build on their research by exploring hypotheses using data from multiple contexts when possible. Their U.S. sample was the MTPS, which we used in this article. Their two non-U.S. samples unfortunately did not contain measures of political knowledge.

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